PAR@METER: a wireless system for fAPAR and LAI continuous monitoring

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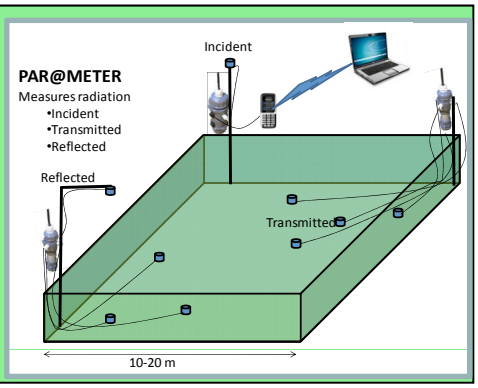
Need for fAPAR and LAI monitoring from ground

Ground measurements of photosynthetically active radiation (PAR) balance and leaf area index (LAI) are required for validating, and sometimes calibrating biophysical products derived from satellite observations. Non destructive methods are either based on instantaneous observations of the directional gap fraction from which the fraction of PAR absorbed by the canopy (fAPAR) is approximated by the PAR interception efficiency (fIPAR). LAI can also be derived from gap fraction measurements, leading to estimates of the effective LAI, or to an approximation of the actual LAI under a number of assumptions on leaf clumping and presence of woody elements. Current devices dedicated to gap fraction (and LAI) measurements are generally 'instantaneous': hemispherical photos or light transmittance (LAI2000, TRAC, ACUPAR…) systems operate within one 'shot'. Such systems allow easy replications over several places to account for spatial variability and get better representation of the average value of areas corresponding to a single or few high spatial resolution (5-50m) satellite pixels, However, they are very tedious to operate when describing the seasonality of fAPAR and LAI, which is mandatory for a number of studies. Alternatively, classical PAR balance could be installed at the site level by distributing individual PAR sensors on the ground, which are connected to a data logger. However, this system is relatively tedious to install because of the wires, has limited autonomy (both memory and energy wise) and is relatively costly, limiting thus a large spatial coverage.

The PAR@METER system was developed to continuously measure PAR balance and derive the corresponding LAI

PAR@METER System description

- **The system includes:**
  - The master device which stores the data and measured incident PAR
  - The slave devices with 4 PAR sensors connected to measure transmittance and/or reflectance
- **How it works?**
  - The master send a signal every 5 minutes to trigger the slaves
  - The slaves take the measurement, ensuring synchronization with incident radiation
  - The slaves send the measurement to the master and then sleeps (for energy saving)
- **General characteristics**
  - Up to 30 slaves can be controlled by a master system.
  - Communication with the master system via a wireless connection.
  - Range is > 300 m.
  - Autonomy of the system is about 3 months, both energy and memory wise.
  - Individual sensors and data logger are cheap enough to allow larger spatial coverage. (slave=350 Euro; Master=350 Euro)
  - Could transmit data to internet via GPRS

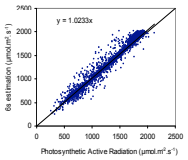


PAR and LAI Measurements

Incident PAR measurement

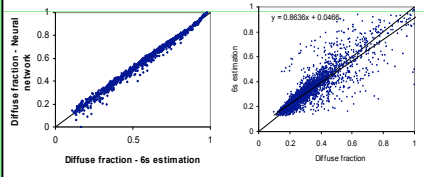
Hemispherical incident PAR

Calibration with 6S model simulations and AERONET atmospheric characteristics (θ_s<60°)



Incident PAR diffuse fraction

Derivation from exo-atmospheric radiation and semi-empirical model calibrated with 6S

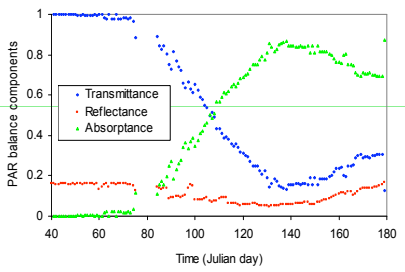


PAR Balance measurement

fAPAR is approximated by:

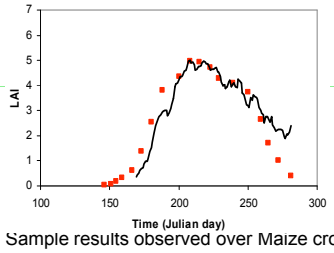
$$fAPAR \approx 1 - R-(1-rs).T$$

Where R is canopy diffuse refelctance, T diffuse transmittance, and rs soil reflectance.
Continuous monitoring over wheat crops
Possible problem: no distinction between green and non green elements



LAI estimation

LAI is derived from the transmttance measurements accumulated over few days. This provides variation of sun position (θ) and diffuse fraction.
Poisson model or dedicated gap fraction models are inverted over these measurements allowing to derive LAI (effective and actual LAI)



Sample results observed over Maize crops

CONCLUSION

PAR@METER systems could be used for products validation and calibration.
It should be easy to set up and allows continuous monitoring temporal evolution of LAI and fAPAR for low canopies.
The system will be commercially available soon (beginning 2010).
Attention should be paid to the spatial sampling, presence of non green elements, and leaf clumping.
Specific system are being developed for forests (fully autonomous systems without commincations)